NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Modulekode:	ITRI626	Metode van aflewering:	Voltyds			Datum:	04/11/2016
Tipe assessering:	Eksamen 1e geleentheid	Vraestelnommer:	1	Sessie:	09:00	Tydsduur:	3 uur

Modulebeskrywing:	Lokaal:
Kunsmatige Intelligensie / Artificial Intelligence	NW205

(1) Gekombineerde Afrikaans/Engelse vraestel		(2) Vraestel vir 'n spesifieke taal			
Aantal studente:	25		Afrikaans	Engels	Ander taal
		Aantal studente:	0	0	0

Benodighede vir vraestel		Aantal per student	Benodighede vir vraestel		Aantal per student
Antwoordskrifte	X	2	Multikeuse-kaarte (A5 – 40 vrae)		
Presensiestrokies vir invulvraestel			Multikeuse-kaarte (A4 – 115 vrae)		
Rofwerkpapier			Grafiekpapier		

Is daar 'n bylaag aangeheg?	Nee	Indien Ja gee 'n kort beskrywing:	

NB: Eksamenafdeling doen geen kontrole wat inhoud of bladsynommers van bylae betref nie.

Sakrekenaars: Ja

Ander hulpmiddels bv. woordeboeke, studiegidse, ens.:		

Inhandiging van antwoordskrifte:	Gewoon
Indien Per dosent, lys Vanne:	

Eksaminator(e):

(1) **DR. JV (TINY) DU TOIT** Bylyn: **992548**

Selfoonnr: Handtekening

Universiteitsnommer:

(2) Bylyn:

Selfoonnr: Handtekening

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Verwysingsnommer: 7.1.9.3.

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Benodigdhede vir hierdie vraestel/Requirements for this paper:			
Antwoordskrifte/ Answer scripts:	X	Multikeusekaarte (A5)/ Multi-choice cards (A5):	
Presensiestrokies (Invulvraestel)/ Attendance slips (Fill-in paper):		Multikeusekaarte (A4)/ Multi-choice cards (A4):	
Rofwerkpapier/ Scrap paper:		Grafiekpapier/ Graph paper:	

Sakrekenaars/Calculators: **Ja/Yes**

Ander hulpmiddels/Other resources:

Tipe Assessering/ Type of Assessment:	**Eksamen 1e geleentheid Exam 1st opportunity Vraestel/Paper 1**	Kwalifikasie/ Qualification:	**B.Sc. Honns, M.Sc**
Modulekode/ Module code:	**ITRI626**	Tydsduur/ Duration:	**3 uur / 3 hour**
Module beskrywing/ Module description:	**Kunsmatige Intelligensie / Artificial Intelligence**	Maks/ Max:	**100**
Eksaminator(e)/ Examiner(s):	**DR. JV (TINY) DU TOIT**	Datum/ Date:	**04/11/2016**
Moderator(s):	**MNR. H. (HENRY) FOULDS**	Tyd/ Time:	**09:00**
Eksterne Moderator(s)/ External Moderator(s):	**PROF. ETIENNE VAN DER POEL**		

Inhandiging van antwoordskrifte/Submission of answer scripts: **Gewoon/Ordinary**

Vraag 1 (Logiese Agente) / *Question 1 (Logical Agents)*

1.1 Hoe word 'n bewys met 'n teenstrydigheid gedoen? Antwoord so volledig as moontlik.

How is a proof by contradiction performed? Answer as comprehensive as possible. [10]

We know that $\alpha \models \beta$ if and only if the sentence $(\alpha \land \neg\beta)$ is unsatisfiable. A sentence in satisfiable if it is true in, or satisfied by, some model. Satisfiability can be checked by enumerating the possible models until one is found that satisfies the sentence. Proving β from α by checking the unsatisfiability of $(\alpha \land \neg\beta)$ corresponds exactly to the standard mathematical proof technique of reductio ad absurdum (literally, "reduction to an absurd thing"). It is also called proof by refutation or proof by contradiction. One assumes a sentence β to be false and shows that this leads to a contradiction with known axioms α. This contradiction is exactly what is meant by saying that the sentence $(\alpha \land \neg\beta)$ is unsatisfiable. (10 marks)

1.2 Bewys dat $(P \Rightarrow Q) \land (Q \Rightarrow R) \models (P \Rightarrow R)$ deur van 'n teenstrydigheid gebruik te maak. Toon al jou stappe en redenasies volledig aan.

Proof that $(P \Rightarrow Q) \land (Q \Rightarrow R) \models (P \Rightarrow R)$ by using a contradiction. Show all your steps and reasoning clearly. [20]

We know that $\alpha \models \beta$ if and only if the sentence $(\alpha \land \neg\beta)$ is unsatisfiable. (3 marks)

$\therefore$ Show that $(P \Rightarrow Q) \land (Q \Rightarrow R) \land \neg(P \Rightarrow R)$ is unsatisfiable.
$\therefore$ Show that $(P \Rightarrow Q) \land (Q \Rightarrow R) \land \neg(\neg P \lor R)$ is unsatisfiable.
$\therefore$ Show that $(P \Rightarrow Q) \land (Q \Rightarrow R) \land (P \land \neg R)$ is unsatisfiable.
$\therefore$ Show that $(\neg P \lor Q) \land (\neg Q \lor R) \land (P \land \neg R)$ is unsatisfiable. (3 marks)

Consider the following truth table (10 marks):

P	Q	R	¬P	¬Q	¬R	(¬P ∨ Q)	(¬Q ∨ R)	(P ∧ ¬R)	(¬P ∨ Q) ∧ (¬Q ∨ R) ∧ (P ∧ ¬R)
T	T	T	F	F	F	T	T	F	F
T	T	F	F	F	T	T	F	T	F
T	F	T	F	T	F	F	T	F	F
T	F	F	F	T	T	F	T	T	F
F	T	T	T	F	F	T	T	F	F
F	T	F	T	F	T	T	F	F	F
F	F	T	T	T	F	T	T	F	F
F	F	F	T	T	T	T	T	F	F

From the truth table it can be seen that (¬P ∨ Q) ∧ (¬Q ∨ R) ∧ (P ∧ ¬R) is unsatisfiable (2 marks).

∴ (P ⇒ Q) ∧ (Q ⇒ R) ∧ ¬(P ⇒ R) is unsatisfiable
∴ (P ⇒ Q) ∧ (Q ⇒ R) ⊨ (P ⇒ R) (2 marks)

1.3 Beskou die volgende proposisies:

Consider the following propositions:

Let P = It is raining.
Let Q = Mary is sick.
Let T = Bob stayed up late last night.
Let R = Paris is the capital of France.
Let S = John is a loud-mouth.

Skryf die volgende Engelse sinne oor in Proposisielogika uitdrukkings deur van bostaande proposisies gebruik te maak:

Write the following English sentences in Propositional Logic expressions by using the abovementioned propositions:

a) John is a loud-mouth but Mary isn't sick. [2]

S ∧ ¬Q

b) It is not the case that Mary is sick or Bob stayed up late last night. [2]

¬(Q ∨ T) or (¬Q ∨ T)

c) Paris is the capital of France and it is raining or John is a loud-mouth. [3]

((R ∧ P) ∨ S) or (R ∧ (P ∨ S))

Vraag 2 (Eerste-orde Logika) / *Question 2 (First-Order Logic)*

2.1 Beskou die volgende predikate en hulle betekenisse.

Consider the following predicates and their meanings.

Predikaat / *Predicate*	Betekenis / *Meaning*
Person(x)	x is a person
Pet(x)	x is a pet
Dog(x)	x is a dog
Cat(x)	x is a cat
Larger(x, y)	x is larger than y
Fed(x, y, z)	x fed y at (time) z

Skryf die volgende Engelse sinne oor in Eerste-orde Logika deur van die bostaande tabel gebruik te maak.

Write the following English sentences in First-Order Logic by using the abovementioned table. [20]

a) If Willy is a dog, then he isn't a person.

   $Dog(Willy) \Rightarrow \neg Person(Willy)$ (5 marks)

b) Every pet is either a dog or a cat.

   $\forall x\ Pet(x) \Rightarrow (Dog(x) \lor Cat(x))$ (5 marks)

c) Willy is larger than every cat.

   $\forall x\ Cat(x) \Rightarrow Larger(Willy, x)$ (5 marks)

d) Elly has never fed Willy.

   $\neg\exists x\ Fed(Elly, Willy, x)$ (5 marks)

<u>Vraag 3 (Inferensie met Eerste-orde Logika) / *Question 3 (Inference in First-Order Logic)*</u>

3.1 Skakel die volgende Engelse sinne om in Eerste-orde Logika:

Convert the following English sentences to First-Order Logic:

1. Lucy* is a professor.
2. All professors are people.
3. Fuchs is the dean.
4. Deans are professors.
5. All professors consider the dean a friend or don't know him.
6. Everyone is a friend of someone.
7. People only criticize people that are not their friends.
8. Lucy criticized Fuchs.

* Name changed for privacy reasons.

Deur van Voorwaardse skakeling gebruik te maak, antwoord die volgende vraag:

By using Forward Chaining, answer the following question:

Is Fuchs not a friend of Lucy?

Toon al jou stappe en redenering duidelik aan.

Show all your reasoning and steps clearly. [23]

Firstly, the Knowledge Base (KB) must be converted to First-order Logic:

1. Is_professor(Lucy) (1 mark)
2. $\forall x$ Is_professor(x) $\Rightarrow$ Is_person(x) (1 mark)
3. Is_dean(Fuchs) (1 mark)
4. $\forall x$ Is_dean(x) $\Rightarrow$ Is_professor(x) (1 mark)
5. $\forall x$ ($\forall y$ (Is_professor(x) $\land$ Is_dean(y) $\Rightarrow$ Is_friend_of(y, x) $\lor$ $\neg$Knows(x, y))) (1 mark)
6. $\forall x$ ($\exists y$ (Is_friend_of(y, x))) (1 mark)
7. $\forall x$ ($\forall$ y (Is_person(x) $\land$ Criticise(x, y) $\Rightarrow$ $\neg$Is_friend_of(y, x))) (1 mark)
8. Criticise(Lucy, Fuchs) (1 mark)

Now, to answer the question: Is Fuchs no friend of Lucy?

Show that: $\neg$Is_friend_of(Fuchs, Lucy)

The existentially quantified variable (y) from sentence (6) is removed by performing skolemization:

6. $\forall x$ (Is_friend(F(x), x)) (1 mark)

The KB is rewritten in First-order definite clauses:

1. Is_professor(Lucy) (1 mark)
2. Is_professor(x) ⇒ Is_person(x) (1 mark)
3. Is_dean(Fuchs) (1 mark)
4. Is_dean(x) ⇒ Is_professor(x) (1 mark)
5. Is_professor(x) ⋀ Is_dean(y) ⇒ Is_friend_of(y, x) ⋁ ¬Knows(x, y) (1 mark)
6. Is_friend_of(F(x), x) (1 mark)
7. Is_person(x) ⋀ Criticise(x, y) ⇒ ¬Is_friend_of(y, x) (1 mark)
8. Criticise(Lucy, Fuchs) (1 mark)

Forward chaining is then done (6 marks):

Fact (1) satisfies rule (2) by using the substitution {x/Lucy} so that the following fact can be added to the KB:

9. Is_person(Lucy)

Fact (3) satisfies rule (4) by using the substitution {x/Fuchs} so that the following fact can be added to the KB:

10. Is_professor(Fuchs)

Facts (1) and (3) satisfy rule (5) by using the substitution {x/Lucy, y/Fuchs} so that the following fact can be added to the KB:

11. Is_friend_of(Lucy, Fuchs) ⋁ ¬Knows(Lucy, Fuchs)

Facts (8) and (9) satisfy rule (7) by using the substitution {x/Lucy, y/Fuchs} so that the following fact can be added to the KB:

12. ¬Is_friend_of(Fuchs, Lucy)

Therefore, according to Fact (12), Fuchs is no friend of Lucy.

3.2 Beskou die volgende probleem:

Consider the following problem:

All people who are graduating are happy.
All happy people smile.
Someone is graduating.

Deur van Resolusie gebruik te maak bewys die volgende. Toon al jou stappe en redenasies duidelik aan.

By using Resolution, proof the following. Show all your steps and reasoning clearly.

Is someone smiling? [20]

First convert the English sentences to predicate logic (4 marks).

∀x Graduating(x) ⇒ Happy(x)
∀x Happy(x) ⇒ Smiling(x)
∃x Graduating(x)
∃x Smiling(x) Negate this: ¬∃x Smiling(x)

1. ∀x Graduating(x) ⇒ Happy(x)
2. ∀x Happy(x) ⇒ Smiling(x)
3. ∃x Graduating(x)
4. ¬∃x Smiling(x)

Then convert to conjunctive normal form (10 marks).

Step 1. Eliminate ⇒

1. ∀x ¬Graduating(x) ∨ Happy(x)
2. ∀x ¬Happy(x) ∨ Smiling(x)
3. ∃x Graduating(x)
4. ¬∃x Smiling(x)

Step 2. Move ¬ inwards.

1. ∀x ¬Graduating(x) ∨ Happy(x)
2. ∀x ¬Happy(x) ∨ Smiling(x)
3. ∃x Graduating(x)
4. ∀x ¬Smiling(x)

Step 3. Standardize variables apart.

1. ∀x ¬Graduating(x) ∨ Happy(x)
2. ∀y ¬Happy(y) ∨ Smiling(y)
3. ∃z Graduating(z)
4. ∀w ¬Smiling(w)

Step 4. Skolemize.

1. ∀x ¬Graduating(x) ∨ Happy(x)
2. ∀y ¬Happy(y) ∨ Smiling(y)
3. Graduating(NoName1)
4. ∀w ¬Smiling(w)

Step 5. Drop all ∀.

1. ¬Graduating(x) ∨ Happy(x)
2. ¬Happy(y) ∨ Smiling(y)
3. Graduating(NoName1)
4. ¬Smiling(w)

Step 6. Distribute ∧ over ∨. (not needed)

Step 7. Make each conjuct a separate clause. (not needed)

Step 8. Standardize the variables apart again. (not needed)

Perform the Resolution algorithm (6 marks).

Resolve (4) and (2) using θ = {y/w}:

5. ¬Happy(w)

Resolve (5) and (1) using θ = {x/w}:

6. ¬Graduating(w)

Resolve (6) and (3) using θ = {w/NoName1}:

7. □

Consequently, someone is smiling.

TOTAAL/TOTAL: 100

Verwysingsnommer: 8.1.7.2.2